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FOR THE

STANFORD MEETING

AT

STANFORD UNIVERSITY

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JULY 10, 1943

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The American Physical Society

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STANFORD MEETING, JULY 10, 1943

THE 256th meeting of the American Physical Society will be held at Stanford University, California, in the Physics Department, Room 372, on Saturday, July 10, 1943. Sessions will begin at 10 A.M. and 2 P.M. Following four contributed papers at the morning session, two invited papers will be given by L. Marton and Hardin Jones. The afternoon session will open with an invited paper by K. K. Darrow, which will be followed by the remainder of the contributed papers. Luncheon will be served at Wilson's Restaurant, 135 University Avenue: it is hoped that there will be several very brief talks. Tea will be served by the Physics Department at the conclusion of the afternoon session.

General Rules Relating to Papers

No paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for that meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at the most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of the abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review.*

Subsequent Meetings are scheduled as follows:

257. Chicago. November, 1943.
258. Pacific Coast Meeting. December, 1943.
259. Annual Meeting. New York City. January, 1944.

R. T. Birge,
Local Secretary for the Pacific Coast,
University of California
Berkeley, California

PROGRAMME

SATURDAY MORNING AT 10:00 O'CLOCK

Room 372, Physics Department

Contributed Papers

1. The Validity of Lens Equation and Magnification Formula of Light Optics for Electron Lenses. R. G. E. HUTTER, *Division of Electron Optics, Stanford University.*—The usefulness of the lens equation $(Z_0-ZF_0)\cdot(Z_i-ZF_i) = -F_0\cdot F_i$ of the magnification formula $M=F_0/(Z_0-ZF_0)$ of light optics, and of the simple geometrical image construction based upon these equations, lies in the fact that the set of lens constants-focal points ZF_0', ZF_i, and focal lengths F_0, F_i are characteristics of the lens and are independent of the object position. It has often been shown that these equations also apply to electron optical lenses. These proofs assume, however, that the lens fields are of finite extent on the optical axis and that object and image are outside the lens region. The assumptions are of the nature of sufficient conditions only; i.e., electron lenses exist for which none of these conditions holds and yet the lenses can be characterized by a single set of optical constants. Necessary and sufficient conditions for such lens types are stated and an analytical expression for all lenses is derived. A number of simple magnetic and electrostatic lenses satisfying these conditions are discussed.

2. Optimum Conditions for Apertures of Magnetic Electron Lenses of the Field Form $H(Z)=H_0/(1+(Z/a)^2)$. L. MARTON AND R. G. E. HUTTER, *Division of Electron Optics, Stanford University.*—It has been shown previously that the optical properties of strong magnetic lenses of the field form $H(Z)=H_0/(1+(Z/a)^2)$ can be completely calculated. Such calculations up to now did not include the position of the lens aperture. Furthermore, the size of the aperture was derived from considerations of the aberrations of weak lenses only. By using the complete analytical expression for the electron path through a lens, both location and size of such an aperture can be calculated. This aperture achieves the ray—limiting effect at a maximum value of its diameter. The calculated size and location of the aperture differs considerably from the values currently adopted. Apertures designed on the basis of these calculations have less diffraction defects. Diagrams are given for the aperture size and location in function of such parameters which allow their application to lenses of different strength and magnification.

3. Intensity of High Energy Electrons and Photons at 10,000 Feet. WAYNE E. HAZEN, *University of California.*—A cloud chamber containing eight 0.7-cm lead plates was operated without counter control at an altitude of 10,000 ft. High energy electrons and photons produced cascade showers in the lead plates whereas mesotrons produced only an occasional collision electron. Usually the shower maxima were observed, since the 30 by 30 cm chamber size provided a large solid angle and there was sufficient lead to produce maxima even in showers of several hundreds of particles. In 8500 photographs, 1090 showers that reached a maximum of four or more particles were observed. If we use the number of particles at the maximum as a measure of the energy of the incident particle, the differential energy spectrum for electrons plus photons of energy 2×10^8 to 10^9 ev follows an $E^{-2.4}$ distribution. When combined with Greisen's[1] counter data for electrons with energy greater than 2×10^7 ev, the present results indicate an $E^{-2.6}$ distribution. The intensity of electrons plus photons with energies greater than 2×10^8 ev relative to penetrating particles was found to be 8.5 percent.

[1] K. Greisen, Phys. Rev. 61, 212 (1942).

4. A Possible New Application of the Wilson Cloud Chamber. CARL E. NIELSEN, *University of California.*—It is well known that the atmosphere contains objects that serve as condensation nuclei with very small supersaturations. Such nuclei—which have interested physicists primarily in being objects that must be removed before the Wilson cloud chamber is useful for the study of ions—may, it is commonly supposed, be inert dust particles as well as salt particles and certain other chemicals. However, it has been asserted that condensation cannot occur upon "ordinary" dust particles. The experiments to be described have shown that dust (carbon) particles 0.5 micron in diameter, and also bacteria of dimensions 0.5 micron to 2 microns do serve as condensation nuclei with small supersaturations. Consequently it is possible to use the cloud chamber to precipitate bacteria from the air upon a petri dish containing agar culture medium. Unlike most common air sampling techniques, which give an unknown percent removal, this method removes *all* of the bacteria from the air.

Invited Papers

Recent Developments in Electron Microscopy

L. MARTON, *Division of Electron Optics, Stanford University*

The Applications of Nuclear Physics to Medicine and Biology

HARDIN JONES, *Radiation Laboratory, University of California*

SATURDAY AFTERNOON AT 2:00 O'CLOCK

Invited Paper

Entropy and Probability

K. K. DARROW, *Bell Telephone Laboratories*

Contributed Papers

5. Townsend Currents in Non-Uniform Electric Fields. PAUL L. MORTON, *University of California.* (*Introduced by Leonard B. Loeb.*)—The current in the Townsend discharge in nearly uniform fields and in the absence of secondary effects can be calculated from the equation $\log i/i_0 = \int \alpha dx$, where the coefficient α as a function of the field intensity can be taken from the experimental work of Hale and others. Uniform fields seldom occur because of space charge distortion as well as electrode shape. The accuracy of this calculation has therefore been investigated for the field between concentric cylinders, in hydrogen at pressures from 0.01 to 10 millimeters, with currents sufficiently small to avoid space charge effects. The results indicate that large errors should be expected when the field intensity near the cathode changes by more than 10 percent per electron mean free path even when the gap is comparatively long, and that the calculated currents can be orders of magnitude off when the electrons reach the anode before attaining a terminal drift velocity corresponding to the field there. If the field changes rapidly only near the cathode and the gap is long, the total ionization as calculated may be approximately correct, even when its location, as indicated by the magnitude of α, is greatly in error. This fact accounts for the approximate agreement sometimes found when the Townsend equation is applied to glow discharges.

6. Apparent Failure of the Meek Criterion for Streamer Formation. LEON H. FISHER, *University of California.*—The criterion for streamer formation given by Meek is that the positive space charge field of an electron avalanche be equal to K times the impressed field. Measurements of streamer onset in confocal paraboloid gaps by Weissler and Loeb[1] indicate that K is extremely pressure dependent. In hydrogen and dry air, K decreases rapidly with decreasing pressure. The possibility existed that the method used in calculating the space charge field in a non-uniform gap was not valid. To test this, the cathode of the least uniform gap of Weissler and Loeb was illuminated with ultraviolet light, and measurements of the current below onset were made in hydrogen. The results indicate that the ionization in these divergent fields cannot be calculated by integrating the ionization functions for uniform fields. At a constant pressure, the current-voltage curve increases too rapidly with voltage. This effect becomes more pronounced with decreasing pressure. Morton has obtained similar results (paper No. 5) in much less divergent fields in hydrogen at pressures near one millimeter. The present results explain the observed trend in K, and restore the possibility of its physical significance. Measurements in air were also attempted, but no currents below streamer onset could be measured. This observation can be explained by electron attachment to oxygen molecules in the weak portion of the field.

[1] Weissler and Loeb, Phys. Rev. 62, 300 (1942).

7. The Effect of Adsorbed Gas on the Contact Electrification of Quartz on Nickel. DAVID E. DEBEAU, *University of California.*—The contact electrification of quartz particles in falling from one Ni container to a second Ni container has been measured as a function of gas pressure. When the gas used is air or O_2, the magnitude of the charge collected is a minimum at pressures of about 0.1 to 1.0 mm of Hg. The charge collected at 10^{-5} mm and at 760 mm is

approximately the same. The maximum charge collected in one run is about 80 e.s.u. and the quartz and the Ni receiver become positive. When H_2 is used, no consistent results are obtainable and the charge collected is low. Not until the chamber is baked out in the presence of air are consistent results again obtainable with air or O_2 in the chamber.

8. Time Variation of Fog and Pressure in a Wilson Cloud Chamber. MORRIS NEUSTADT, *University of California.*—Fog and pressure were measured electrically, and were observed as traces on an oscilloscope, an electron switch showing them simultaneously. The chamber was operated (1) saturated with water, (2) dry, (3) saturated with alcohol-water solution, 3 to 1 by volume. All measurements were made both for expansion to constant final volume, and to constant final pressure. Expansion ratios ranged from below the ion limit to above the fog limit. The larger the expansion ratio the larger is dp/dt after expansion. When large fog is present there is a rapid build-up of pressure due to heat of condensation of the fog. This effect on the pressure is not present when a dry chamber is used. If one expands below the ion limit, dense fog present from a previous over-expansion causes the pressure minimum to be higher, and causes the pressure to rise very sharply for a short time. As R increases, the fog builds up sooner and has a larger maximum value. Initially the fog increases as t^2, but during the sensitive time this relationship gradually changes, and the fog increases as t after the end of the sensitive time. Constant pressure fogs scatter more light than constant volume fogs.

9. Spectrographic Determination of Lead in Pectinous Materials. C. RULON JEPPESEN* AND E. JOHN EASTMOND, *Western Regional Research Laboratory.*—A spectrographic method of analysis for lead in pectinous materials has been developed which utilizes dry-ashed samples and thus avoids possible contamination from chemical treatments and the difficulties encountered in putting certain of these materials into solution. The dry-ashed sample is mixed with four times its weight of a standard buffer base consisting of 0.175 percent bismuth in lithium carbonate. A 250-volt d.c. arc between graphite electrodes is used as a source of excitation. The ratio of the intensities of the lines Pb 2833A and Bi 2898A is determined from photometric measurements of the spectrogram and the concentration of lead is read from a previously prepared working curve. Concentrations of lead as low as 0.01 part per million in the original sample and 60 parts per million in the ash have been measured. Repeat analyses on the same sample show an average deviation from the mean of approximately 15 percent when triplicate exposures are used. Tests indicate variations are due chiefly to the ashing and mixing processes. The method is rapid and entirely objective.

* Now at Montana State University, Missoula, Montana.

10. Contribution to the Theory of Liquids. AHLBORN WHEELER, *Shell Development Company, Emeryville, California.* (*Introduced by O. Beeck.*)—To date all theories of the liquid state have been seriously handicapped by the fact that we cannot assign the correct statistical weight (entropy) to a given arrangement (energy state) of the molecules in our system. It is shown how this can be done for the simplest type of liquid system: a linear chain of molecules with arbitrary interaction potential between nearest neighbors. The exact partition function is constructed for this system and the thermodynamic properties are calculated for potential functions of the Lennard-Jones type. The nucleus of the solution is an exponential integral of $(E+pV)/kT$ over the coordinate space, and this integral gives the Gibbs free energy directly. The results should be of considerable assistance in formulating improved theories for real liquids. First of all the form of the solution is very suggestive in indicating how to construct new and perhaps more accurate partition functions for the three-dimensional case. Secondly we have a "yardstick" with which to test the validity of any approximate model of a liquid. This model may be applied to our one-dimensional system, and the results compared with the exact solution.

11. Identification of Hydrocarbons by Means of Their Infra-Red Spectra. R. S. RASMUSSEN, R. R. BRATTAIN, AND O. BEECK, *Shell Development Company, Emeryville, California.*—Infra-red absorption spectroscopy in the rocksalt region (2–15μ) has been applied to the rapid qualitative and semi-quantitative analysis of higher isomeric paraffin and olefin hydrocarbons (C_6 to C_8). Spectra of pure hydrocarbons serve as comparisons, against which the spectra of new preparations are checked. Samples which are nearly pure are readily identified in this way, and the type and amount of impurity can be estimated. Since in complex mixtures the bands of the individual hydrocarbons often overlap to a great extent, a rough distillation may be necessary in order to divide the mixture into various cuts which in turn can be examined by the infra-red absorption method. Further use of infra-red spectra can be made in those cases where characteristic bands exist for specific groups. These bands may be used in establishing the structure of molecules. While this procedure is uncertain in the case of paraffin hydrocarbons, it has proved highly useful in the study of olefins. Thus the $C=CH_2$ group (α-position of the double bond) is indicated by a band at 3.2μ and a strong band in the 6μ region. Moreover, several very strong bands in the 10–12.5μ region are highly characteristic of the type of substitution around the double bond.

12. Quantitative Analysis of Multicomponent Mixtures by Means of Infra-Red Spectrophotometry. R. R. BRATTAIN, R. S. RASMUSSEN, AND A. M. CRAVATH, *Shell Development Company, Emeryville, California.*—Provided sufficient differences exist in the absorption spectra of the pure components and provided Beer's law is obeyed, spectrophotometric analysis of a multicomponent mixture of n components can be obtained by making optical density measurements at n wave-length positions, and solving n linear simultaneous equations in n unknowns. For routine work in the infra-red region from 2 to 15μ, desirable stability is gained by using wide spectral slits and no further amplification of the thermocouple output. Under these conditions Beer's law cannot be applied to the absorption

measurements because of the rapid change of the true absorption coefficient over the spectral slit width. In order to analyze mixtures under these conditions, it is assumed that the optical density of the mixture is equal to the sum of the optical densities of the pure components, although the optical density of a component is no longer linear with concentration. Calibration curves can be obtained from data on pure compounds giving optical density as a function of concentration (non-linear) and can be used in the analysis of mixtures. The method has been thoroughly tested on a large number of hydrocarbon mixtures and was found to give excellent results with mixtures of 6 and 7 components. An accuracy of ±0.5 percent (of total sample) is obtained for each component. By using a specially devised rapid method of calculation the time required to analyze a six-component C_4 hydrocarbon mixture is 1½ hours as against 12 to 15 hours by low temperature distillation and subsequent gas analyses.

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